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# Landlockedness, Infrastructure and Trade:

## New Estimates for Central Asian Countries

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## Abstract

This paper assesses the impact of internal infrastructure and landlockedness on Central Asian trade using a panel gravity equation estimated on a large sample of countries (167 countries over 1992-2004). The panel structure of the dataset makes it possible to control for country-pair specific effects (as opposed to the usual importer and exporter effects) that would otherwise be captured by the coefficients of time-invariant variables such as distance or landlockness. Our findings highlight the need to pursue

a dual policy agenda. First, transit corridors are regional public goods and should be managed as such through international cooperation. International Financial Institutions can -and do- play a key role in this regard through assistance, coordination and policy dialogue. Second, the Central Asian countries should actively seek diversification of their transit corridors to prevent the creation or maintenance of monopoly positions in transit and bottleneck points such as trans-shipment platforms.

# LANDLOCKEDNESS, INFRASTRUCTURE AND TRADE: NEW ESTIMATES FOR CENTRAL ASIAN COUNTRIES

Christopher Grigoriou[*]

# 1. INTRODUCTION

The Soviet Union's collapse in the 1990s was expected to lead to a major reorientation of the former bloc's trade, given that politically-determined trade links under central planning had given rise to substantial over-trading between former Soviet Union states. For instance, Fidrmuc and Fidrmuc (2003) estimated that former Soviet Union countries traded 43 times more between them than predicted by GDP and distance. Conversely, Hamilton and Winters (1992) and Baldwin (1994) calculated that potential trade between former Soviet Union countries and the EU was more than four times the actual volume. However, by the late 1990s, if trade with the Soviet Union had indeed shrunk, reorientation was limited as trade with other regions had failed to take off. By 1998, for instance, trade between Russia and former Soviet Union countries, although reduced, was still 30 times greater than 'normal' (Fidrmuc and Fidrmuc 2003).

Designing policies to assist the Central Asian Countries (CACs)[1] to achieve the reorientation of their foreign trade and integrate in the global economy requires an understanding of the nature of their handicaps that goes beyond the mechanical effect of landlockedness. What is needed is an understanding of (i) how the effect of landlockedness interacts with that of poor infrastructure in the CACs and in neighboring (transit) countries; and (ii) what practical policy steps can help mitigating the effect of landlockedness on trade.

The literature so far explains hysteresis in former Soviet Union trade by remoteness and landlockedness[2] (Kaminski, Wang and Winters, 1996; Djankov and Freund, 2002; Grafe, Raiser and Sakatsume, 2005), poor access to markets and incomplete reforms (Havrylishin and Al-Atrash, 1998), weak institutions (Babetskaia-Kukharchuk and Maurel, 2004), poor product quality (e.g. Bevan et al., 2001), and hysteresis in consumption, production and business networks (Djankov and Freund, 2002).

Beyond Central Asia, a voluminous gravity-based literature has also provided estimates, often incidental, of the impact of landlockedness on trade. Typically, these studies included a dummy variable equal to one for landlocked countries. For instance, Carrère (2006) found

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[1] Throughout this paper, by Central Asian Republics, we mean Kazakhstan, the Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan.
[2] Only Kazakhstan and Turkmenistan have access to the Caspian Sea, itself a landlocked sea bordered only by Russia, Azerbaijan and Iran, while Uzbekistan is twice landlocked, i.e. surrounded by countries that are themselves landlocked.

that, on the basis of a panel gravity model, ceteris paribus a landlocked country traded about 28% less than a coastal one. Estimates of similar magnitudes were found in other studies. Clearly, these estimates could explain only a small part of the CACs' under-trading with the rest of the world. Indeed, few of those papers focused explicitly on the impact of landlockedness on trade. One notable exception was Raballand (2003) who analyzed the effect of landlockedness on trade in the case of Central Asian countries. Using a restricted sample of 46 CIS countries, 18 of which landlocked, over a period of 5 years (1995-1999), he found landlockedness to reduce trade by more than 80%. This very large impact, substantially out of step with usual estimates, was at least partly due to the fact that his landlockedness variable was equal to one only for bilateral trade between *two* landlocked countries, while the landlockedness variable in other studies usually marks the bilateral trade of landlocked countries with all their partners, landlocked or not.

Dummy variables in a gravity equation are black boxes that do not tell us much about how landlockedness affects trade. A limited number of studies have shed light on the channels through which its impact is felt. In his study of Central Asian trade, Raballand introduced two other components of landlockedness ---shortest distance to a major port facility and number of borders crossed in transit, and found them to have significant effects. Using CIF/FOB data from the IMF for 97 developing countries, 17 of which landlocked, Radelet and Sachs (1999) estimated that transport and insurance costs were twice as high for landlocked countries as for coastal countries. They concluded that "geographic isolation and higher shipping costs may make it much more difficult if not impossible for relatively isolated developing countries to succeed in promoting manufactured exports". Limao and Venables (2001) found a large effect of infrastructure quality on trade costs, in particular for landlocked countries, on the basis of a cross section of countries with controls for the quality of transit-country infrastructure. Poor infrastructure accounted for 40% of predicted transport costs for coastal countries and up to 60% for landlocked countries. The high impact of remoteness and infrastructure on trade costs was also evidenced by Brun et al. (2005). Using IMF estimations of freight payments as a percentage of imports, Stone (2001) found a comparable transport cost burden. The transport costs were lower in transit states than in landlocked countries in 75% of the cases, from the 64 possible comparisons between landlocked countries and transit countries.

In this paper, we revisit the evidence using a large panel of bilateral trade flows between 167 countries over 13 years spanning 1992-2004. Particular attention is given to the econometric specification of the gravity model in order to eliminate sources of biases common in conventional gravity models. In particular, we take advantage of the sample's panel structure to include country-pair specific effects instead of the usual exporter and importer effects (making the identification of time-invariant country characteristics like landlockedness possible) and treat carefully the potential endogeneity of some of the explanatory variables. Using this careful specification, we assess the impact of domestic infrastructure and landlockedness on Central Asian trade and provide a decomposition of landlockness' impact on transport costs into several components, such as overland distance to port or transit-country infrastructure.

Our empirical results show that an improvement in the own infrastructure of Central Asian countries from the level of the median Central Asian country to that of the top 25th percentile among other landlocked countries would raise exports (imports) by a modest 6.5% (8.6%).[3] An improvement in infrastructure quality to the level of the median coastal country would raise exports (imports) by 14.5% (19.6%). Thus, the impact of domestic infrastructure appears limited.[4] By contrast, an improvement in transit-country infrastructure to the level of the best 25th percentile amongst other landlocked countries would raise the representative CAC's exports by a whopping 52%. Other dimensions of landlockedness are also great impediments to the trade of Central Asian countries. Hence, diminishing the extra overland costs (proxied by the distance to the nearest port) or enhancing the ability of a landlocked country to negotiate sea access compared to others landlocked countries would significantly increase Central Asian trade, "transit monopolies" (single transit corridors) reducing trade significantly.

Although these estimates are subject to the usual caveats, their policy message is clear. First, transit infrastructure is a regional public good and should be managed as such. Facilitating regional cooperation between landlocked and transit countries for the upgrading of transit infrastructure should thus remain a clear policy priority for the IFIs. Second, monopolies in transit corridors are costly. Short of an often doomed quest for transit corridor

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[3] Maintaining all other variables at the level of the representative Central Asian country (median value).

[4] And not specific to landlocked countries as the associated coefficient is the same for all countries in the sample.

diversification (in a region where many potential routes to seashores are marred by instability and conflict) the IFIs' recent emphasis on improving the business environment for transit services is vindicated, as a policy priority, by our estimates.

The paper is organized as follows. Section 2 presents some stylized facts on infrastructure and geographical disadvantages of Central Asia. Section 3 develops the assessment method of the impact of infrastructure and landlockedness on the Central Asian trade. Section 4 details the results. Section 5 provides some concluding remarks and suggests some induced policy recommendations.

## 2. STYLIZED FACTS ON INFRASTRUCTURE AND GEOGRAPHICAL DISADVANTAGES OF CENTRAL ASIA

High transport costs are certainly one of the main impediments to the reorientation of Central Asian trade. The distance of Central Asian countries from the main economic markets is of course only part of the story[5]. The density and quality of internal infrastructure are also determining factors of Central Asian trade costs, though perhaps more important in terms of trade policy. Limao and Venables (2001) emphasized that distance explains only 10% of changes in transport costs. Poor road infrastructure represents 40% of the transport costs predicted for coastal countries and 60% for landlocked countries. We shall show that this is particularly relevant for Central Asian countries.

However, distance and infrastructure alone do not explain why Central Asian countries are at a disadvantage even compared to countries with similar infrastructure endowments or which are similarly remote but which have sea access. Once low incomes, a poor internal infrastructure network, distance and remoteness are controlled for statistically, landlockedness still has a negative and highly significant impact on trade (see Limao and Venables 2001, Raballand 2003 or Carrère 2006). There are many reasons for this. For instance, overland distances are more penalizing than sea distances because of their higher costs per mile. Moreover, landlocked countries are dependent on sovereign transit countries for their trade, a dependency that may only serve to compound existing problems.

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[5] See Figure 1 in Appendix A1 for an illustration of the main route corridors and distances for international freight movements to and from the main trade centers of the region. The five Central Asian countries are clearly remote from the main global markets.

We present direct estimates of transport costs for Central Asia in Section 2.1.. The internal infrastructure of Central Asian countries is analyzed in Section 2.2., while the specific costs of landlockedness are discussed in Section 2.3.

## 2.1 Direct estimates of Central Asian transport costs

Direct estimates of transport costs have been gathered from a survey of transport firm managers along various routes linking Europe and Central Asia (see Raballand et al., 2005). They show that the cost of transporting a 40' container by road rises by and large linearly with the distance; a slightly higher derivative was recorded for the Central European leg of the journey (between Warsaw and Moscow). However, the cost of transporting a 20' container by rail rises less than proportionately with the distance after the Moscow leg. Although Raballand et al. do not offer any reasons why this is the case, it is likely that these cost differences reflect the politically motivated subsidization of freight rates in the former CIS.[6]

The same picture emerges for transport times. Unlike costs, time rises more than proportionately with distance after the Moscow leg, which reflects more difficult conditions for both rail and road cargo. Similar observations have been made for the trade route between the US and Central Asia.[7] Aside from a change in transport costs and time per kilometer, it is worth noting that long distances produce extremely high transport costs (USD 6,000 for a 40' container from Paris to Tashkent, a prohibitive level for most types of cargo).

## 2.2 Internal infrastructure: a common component of transport costs across all countries

The relation between infrastructure and trade are supported by both theoretical (e.g. Bougheas, Demetriades and Morgenroth, 1999) and empirical evidence (see Limao and Venables, 2001). Limao and Venables (2001), using a combination of shipping data and

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[6] It should be noted, however, that freight rates on routes between Moscow and Central Asian capitals are differentiated in terms of cargo, with low rates applying to primary product shipments (e.g. cotton from Uzbekistan) from Central Asia to Russia. We are grateful to Eskender Trushin from the Tashkent Bureau of the World Bank for pointing this out.
[7] For instance, Stone (2001) notes that freight rates per mile are twice as high for a container shipped to Bishkek (Kyrgyzstan) than for one shipped to Ankara.

CIF/FOB ratios, have shown that a deterioration in the infrastructure from the median to the 25th percentile raised transport costs by 12 percentage points and reduced trade volumes by 28 percent. The issue of inadequate infrastructure is of particular relevance for Central Asia.

*Density*

Estache and Goicoechea (2005) have shown that Central Asia has low levels of transport and communications' infrastructure. For instance, railway density is on average 5.4 rail-km per 1,000 km², i.e. one-third of the average railway density of low- and middle-income countries. This is a particular cause for concern given that approximately 90% of total freight transport in Central Asian countries during 2000 was by rail (see Raballand et al. 2005). It is therefore fair to say that low infrastructure levels are likely to affect Central Asian trade, and that the lack of investment in existing infrastructure increases transport costs.

Moreover, it can be shown (see Appendix 2) that even after controlling for low income levels, the density of infrastructure in Central Asia remains severely lacking.

*Maintenance and services*

Low network density is only part of the problem, which is compounded further by the poor quality of the transport infrastructure. The Asian Bank of Development Bank (2006) documented a trend of deteriorating material and infrastructure, primarily as the result of inadequate maintenance (notably for railway infrastructure). According to Pomfret (2005), the insufficient funding earmarked for infrastructure maintenance is a phenomenon common to all former Soviet countries, where national networks often take precedence over regional networks. In some instances, governments even opted to set up alternative roads or railway lines to avoid crossing neighboring countries (largely for political reasons) despite the existence of regional lines. Consequently, existing infrastructure were left to deteriorate progressively.

Inadequate road maintenance has far-reaching implications for trade and transaction costs. As amply demonstrated in Sub-Saharan African contexts, bad roads result in damaged trucks and increased time spent on maintenance, thereby reducing the productive capital rate of return. In turn, this hampers the ability of intermediaries to link isolated producers (especially farmers) to markets. In extreme cases, markets may suffer total collapse, leading

to the formation of isolated pockets of subsistence. These autarkic sub-economies are usually characterized by extreme poverty (Cadot, Dutoit and de Melo 2005; Cadot, Dutoit and Olarreaga 2005). Such trends have been observed in Kazakhstan, where Raballand et al. (2005) documented the evolution of traffic density in the Kyzyl-Orda region. The region has the lowest road density in Kazakhstan (11.4 km per 1,000 km²), mainly due to the lack of maintenance to rural roads. The trucking fleet worsened and shrunk from 2,456 units in 1990 to 601 in 2000 (Satubalding and Zhandaulet, 2002; pp.67-68).

Trade costs not only depend on the quality of the "hard" infrastructure (roads, railroads, airports, etc.) but also on the "soft" aspects of the transit sector's business environment. A recent report by the Asian Development Bank (2006) on regional cooperation in trade, transport and transit, outlines the results of a "logistics friendliness" survey (based on data provided by approximately ten companies involved in international transport and trade in Central Asia). Central Asian countries were surveyed during late 2004-early 2005 with the aim of assessing the affordability, speed and reliability of their logistics' services. According to the survey results, Central Asian republics rank lower than Russia in all three dimensions. Kazakhstan and the Kyrgyz Republic rank best in the region, whereas Tajikistan ranks worst.[8] Moreover, reliability consistently appears as the most troublesome issue, suggesting the presence of severe managerial problems that could potentially be tackled through capacity-building programs. [9]

*Network structure*

Finally, Central Asia has inherited a network structure that was designed for the needs of the Soviet Union, but is not necessarily optimal once market forces have realigned trade flows according to the principle of comparative advantage. The problem is inherent in any geographical area undergoing economic change and industrial relocation. For former Soviet-bloc countries, however, it has been all the more severe as trade flows and industrial location were the result of central planning, which involved highly distorted prices (also for transport services) and paid scant attention to economic efficiency. Moreover, independence

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[8] These results are broadly consistent with the results of a similar survey reported in Ojala, Naula and Queiroz (2004).
[9] Given the lack of available data on road and rails maintenance for such a database, we use the indicator from Limao and Venables (2001). It is commonly used since in the literature to assess the infrastructure level in international trade studies, even if it focuses on quantitative aspects of infrastructre rather than on qualitative ones.

and poor neighbour relations (see below) have rendered previously free-of-charge border crossings between Soviet provinces highly costly. The World Bank (2004a) provides a striking illustration. As the network configuration was initially implemented to satisfy the former Soviet Union's industrial and strategic plans, little consideration was given to transport costs or to passengers' needs. As a result, there are often no straightforward connections between locations within a country, while roads and railways cross new CIS borders several times. For instance, 800 kilometers of Russian railways are on Kazakh territory, while 300 kilometers of Kazakh railways are on Russian territory.

## 2.3 Additional costs of landlockedness in Central Asian countries

Landlocked countries often lag behind their maritime neighbors in terms of external trade and economic development, even when they have similar distances to main trade partners or similar internal transport infrastructure. The reason is that landlocked countries also have to cope with long overland distances (notably to join ports) and are largely dependent on sovereign transit countries, which they have to cross in order to access international shipping markets (see Faye et al., 2004, Ojala, 2005, or Carcamo-Diaz, 2004 for surveys on the various forms of transit dependency).

*Overland distance*

Landlockedness affects many countries, but some, such as Switzerland, nonetheless manage to prosper. However, the story is altogether different for Central Asia. Except for Batumi on the Black Sea (which can be reached only after trans-shipment over the Caspian Sea), all ports are more than 3,000 km away from their closest Central Asian border. Many are even farther away, the shortest route to the sea being the Southern one which happens to go through what is probably the most unstable region of the world. Such huge land distances imply problems of a different magnitude than those faced by European landlocked countries like Switzerland and the Czech Republic, which are 500-600 km away from major ports.

In terms of monetary transport costs (one dimension of the problem, although by no means the only one), Limao and Venables (2001) estimated that overland transport costs rise by as much as $1,380 per 1,000 km compared to only $190 for overseas transport.

Finally, freight costs lie roughly in the $1,000-3,000 range for distances between 3,000 and 5,000 km, suggesting average rates of less than $500 per thousand kilometers. Although the shortest route is the Afghan one to Karachi via Quetta, the Bandar Abbas rail route appears the most attractive. Taking this as a basis for our calculations, maintaining the freight rate below 10% of shipment value (a high rate given that it covers only overland transport to the port of destination) implies a cargo worth at least $15,000, a very high value for a 20' container – and one that would be risky to ship on a hazardous route.

*Transit infrastructure*

Landlocked countries are completely dependent on their transit neighbors' infrastructure to transport their goods to the nearest port. There are many causes of weak infrastructure, including lack of resources, poor governance, conflict and natural disasters. Regardless of the cause, weak infrastructure impose direct costs on trade passing through transit countries and thus limit the ability of products from landlocked countries to compete in global markets. The relative impact of the weak infrastructure of its neighbors has a particularly negative impact on those landlocked countries which mainly export primary commodities with low value-to-cost ratios rather than high-value products or services. A weak infrastructure of a transit country also limits the return to investment in landlocked countries' internal infrastructure due to the restrictions it places on market opportunities. The data yielded by CIF/FOB ratios allowed Limão and Venables (2001) to estimate that improving the infrastructure of transit countries, all other things being equal, would reduce the transport cost differential between the median landlocked economy and the median coastal country from 46% to 43%, and thus lead to a 2% increase in trade volume.

Transport infrastructure in the Central Asia sub-region has been heavily influenced by the needs of the former Soviet Union, with road and rail networks designed to facilitate traffic flows towards the European part of Russia, particularly Moscow and Ukraine. Road and rail connections are less well developed both within Central Asia itself, and between Central Asia and its neighbours to the east and south. Connections through China, Iran, Afghanistan and Pakistan are limited and poorly developed. There is one major paved road corridor through the sub-region, running east to west and linking Tashkent to Almaty, with connecting roads to China and Turkmenistan. There is also a single rail corridor to China, passing through the high mountains of the Kazakh-China border. For more details on the major trade corridor for Central Asian Trade, see Ojala (2005).

However, the practicability of transit corridors depends not only on the physical infrastructure of transit countries but also on their political climate and on the quality of their governance, which, in the case of Central Asia's transit partners, is a particular cause for concern.

*Difficult neighbor relations*

Landlocked countries are heavily dependent on their political relations with transit countries. If there is conflict, whether military or diplomatic, between a landlocked country and its transit neighbors, the latter can easily block borders or set up regulatory impediments to trade. Even where there is no direct conflict, landlocked countries are vulnerable to the political vagaries of their neighbors. According to Faye et al. (2005), "although there is a legal basis for rights of landlocked transit as outlined in Article 125(1) of the United Nations Convention on the Law of the Sea (United Nations, 1982), in practice, this right of access must be agreed upon with the transit neighbour (Article 125(2) and (3)) and is determined by the relationship between the countries."

As these authors also pointed out, Central Asian Republics have been badly affected by cross-border disputes. After the collapse of the USSR, the former Soviet republics were divided along previous administrative boundaries, which have since been the source of many disputes. As a result, borders are regularly defended with landmines and physical blockades. Ongoing tensions have also resulted in a general failure of regional cooperation.

*Many borders to cross*

Politically-motivated obstacles aside, landlocked countries have to deal with the direct costs of crossing the national borders of transit countries. Using different specifications of the gravity model, a number of empirical studies (McCallum 1995, Anderson and Van Wincoop 2003) have sought to estimate the trade-reducing effect of border crossings by comparing cross-border trade with intra-national trade across regions. Even for relatively "trade-friendly" borders, such as the Canada-US border, these authors found that borders inhibit trade by very large orders of magnitude.

Whatever the route taken by Central Asian trade, in all cases several borders have to be crossed, compounding the inhibiting effect of borders. The costs involved are multiple, with

a host of direct transit and customs charges (for an exhaustive review of all transit trade costs faced by landlocked countries, see UNCTAD 2004). A comparison of these costs is shown in Appendix 3. Although the sample is too small to draw any general conclusions, the two Central Asia data points (Kazakhstan-Russian Federation and Uzbekistan-Turkmenistan) suggest that the costs are very high.

Moreover, border crossings also cause long delays to transit traffic (see Appendix 4). It is regularly observed that time delays and the variability of transit times are of greater concern to traders than direct costs, as they hinder the ability to meet delivery contracts without large inventory stocks (see Hummels, 2001).

Finally, according to the World Bank (2005), the most serious problem relates to customs and the incidence of unofficial payments, which is extraordinarily pernicious in Central Asia. This handicap compounds other customs-related impediments, such as the lack of coordination among border-related agencies, complexity of customs' procedures, lack of transparency in customs' codes and regulations, low utilization of information technology in customs' operations, as well as long transit times.

### Limited choice of transit corridors

Finally, the limited choice of transit corridors does not allow Central Asian countries to negotiate with transit countries. Some new transit agreements are in development, but at the present time a number of transit countries continue to exercise a monopoly. As noted by UNESCAP 2003, this restricted competition in Central Asia *in the provision of transit transport services* between operators, modes of transport and routes may result in inefficient pricing policies and services.

### 3. ASSESSING THE IMPACT OF INFRASTRUCTURE AND LANDLOCKEDNESS ON CENTRAL ASIAN TRADE

In this section we will address two important issues. First, to what extent is Central Asian trade affected by the level of internal infrastructure network? Second, how far is it reduced by higher transport costs due to landlockedness?

The gravity equation provides a general empirical framework and is especially suited to the examination of these issues. This model allows us to identify the impact on bilateral trade of variables, such as infrastructure and landlockedness, once all other structural determinants

of trade, mainly GDP, distance and remoteness, are controlled for. The gravity model is presented in detail below.

### 3.1. Derivation of the gravity equation with infrastructure and landlockedness

We use the gravity model as a simple and efficient tool to predict the volume of bilateral trade and to assess the burden of landlockedness (see surveys proposed by Evenett and Keller, 1998, Anderson and van Wincoop, 2004, and Feenstra, 2004). We adopt the popular version of the gravity model currently applied when aggregating trade between economies with an assumed specialization in differentiated products. As shown by Deardoff (1998), as well as Anderson and Van Wincoop (2003, 2004), the utility maximization of an identical (over countries) CES utility function yields the following expression for bilateral imports,

$$M_{ijt} = \left( \frac{Y_{it} Y_{jt}}{Y_{wt}} \right) \left( \frac{\theta_{ijt}}{R_{it} R_{jt}} \right)^{1-\sigma} \qquad (1)$$

where $M_{ijt}$ is the CIF (cost, insurance and freight) value of the aggregate merchandise trade flow imported by country i from exporter j; $Y_{i(j)t}$ is the gross domestic product of country i (j) in t; $Y_{wt}$ is the world income in t, $\theta_{ijt}$ is bilateral transport costs; $\sigma$ is the elasticity of substitution in the CES utility function; and $R_{it}$, $R_{jt}$ can be interpreted as "multilateral trade resistance" or "remoteness" indices. Following Helliwell (1998), Brun et al. (2005), and Carrère (2006), the remoteness index is defined as the weighted distance to all trading partners of country i:[10]

$$R_{it} = \sum_{j} w_{jt} D_{ij} \text{ for } i \neq j \text{ and with } w_{jt} = \frac{Y_{jt}}{\sum_{j} Y_{jt}} \text{ for all } i. \qquad (2)$$

Positive signs are expected: for a given distance $D_{ij}$, the more remote a pair of countries is from the rest of the world, the more they will trade with each other.

The estimation of equation (1) raised issues related to the estimation of bilateral transport costs, $\theta_{ijt}$. In the standard implementation used, among others, by Baier and Bergstrand (2002) or by Anderson and Van Wincoop (2003), transport costs include distance ($D_{ij}$) along with a vector of dummy variables for common borders ($B_{ij}$, equal to 1 if countries i and j share a common border, otherwise 0) and landlockedness ($L_{i(j)}$, equal to 1 if country i (j) has no direct sea access, otherwise 0). Nevertheless, Limao and Venables (2001) emphasized that distance explains only 10% of the change in the transport costs. Poor road infrastructure

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[10] For a detailed discussion on this approximation see Brun et al. (2005) or Carrère (2006).

represents 40% of the predicted transport costs for coastal countries and 60% for landlocked countries. This is especially relevant for Central Asian countries that have particularly high transport costs over a given distance owing to geographical obstacles, landlockedness and weak infrastructure. Therefore, we go beyond the standard specification by including an index for the quality of infrastructure in period t, $K_{i(j)t}$, as suggested by Limao and Venables (2001), Brun et al. (2005), and Carrère (2006) The infrastructure measure we use is designed to measure the costs of travel in and through a country[11]. It is constructed as an average of the density of the road network, the paved road network, the rail network, and the number of telephone main lines per person.[12] Higher values of the index indicate a better infrastructure. Note that the cost of oil, which is arguably the main determining factor of the marginal cost of transport, is controlled for by the time dummies in the model (see below). Thus, the transport cost function, assuming the standard multiplicative form, yields:

$$\theta_{ijt} = D_{ij}^{\alpha_1} e^{\alpha_2 B_{ij} + \alpha_3 I_{it} + \alpha_4 I_{jt}} \left(1 + K_{it}\right)^{\alpha_5} \left(1 + K_{jt}\right)^{\alpha_6} \qquad (3)$$

with the expected signs: $\alpha_1 > 0,\ \alpha_2 < 0,\ \alpha_3 > 0, \alpha_4 > 0, \alpha_5 < 0,\ \alpha_6 < 0$.

Note that alternative measures to capture different components of landlockedness and to better identify its impact on transport costs and, consequently on trade, are developed in Section 3.2..

We replace the bilateral transport costs $\theta_{ijt}$ in equation (1) by its expression in equation (3), and we estimate the following equation:

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[11] The infrastructure variable was introduced in a gravity model by Limao and Venables (2001). They construct an infrastructure measure as an average of the density of the road network, the paved road network, the rail network and the number of telephone main lines per person. They estimate the effect on bilateral trade of this indicator with a 1990 dataset for a sample of 103 countries. Their analysis of bilateral trade reveals the importance of infrastructure: a deterioration of infrastructure from the median of the sample to the 25th percentile reduces trade volume by 28%. This infrastructure indicator is also introduced in a gravity model by Brun et al. (2005) and Carrère (2006) but extended to cover 180 countries over the 1962-1996 period. These studies confirm the significant positive impact of infrastructure on bilateral trade. However, the estimated elasticity is lower than that found by Limao and Venables (2001). There are two main reasons behind this disparity: (i) the use of both the cross-section and the temporal dimensions of the infrastructure development allows Brun et al. (2005) or Carrère (2006) to capture the impact of this variable on bilateral trade more accurately (while controlling for country-specific effects); (ii) the endogeneity of the infrastructure variable is corrected for in these two studies. In the next section we base our infrastructure analysis on the Brun et al. (2005) and Carrère (2006) method, with particular focus on Central Asian countries.

[12] Given the construction of the variable, we used $1+K_{i(j)t}$ in empirical work. In fact, when $K_{i(j)t}$ tends towards 0, ln $(1+ K_{i(j)t})$ tends to 0. Appendix A3 describes in detail how this index was constructed.

$$\ln M_{ijt} = \beta_0 + \beta_1 \ln Y_{it} + \beta_2 \ln Y_{jt} + \beta_3 \ln R_{it} + \beta_4 \ln R_{jt} + \beta_5 \ln D_{ij}$$
$$+ \beta_6 B_{ij} + \beta_7 L_i + \beta_8 L_j + \beta_9 \ln\left(1 + K_{it}\right) + \beta_{10} \ln\left(1 + K_{jt}\right) + \omega_{ijt} \qquad (4)$$

where $\omega_{ijt}$ is the error term (assumed to have a standard normal distribution), and with the following expected signs: $\beta_1$=1>0, $\beta_2$=1>0, $\beta_3$=($\sigma$-1)>0, $\beta_4$=($\sigma$-1)>0, $\beta_5$=(1-$\sigma$)α$_1$<0, $\beta_6$=(1-$\sigma$)α$_2$>0, $\beta_7$=(1-$\sigma$)α$_3$<0, $\beta_8$=(1-$\sigma$)α$_4$<0, $\beta_9$=(1-$\sigma$)α$_5$>0, and $\beta_{10}$=(1-$\sigma$)α$_6$>0 .

We also check the robustness of our results by adding other variables usually found in empirical literature (such as populations and the bilateral real exchange rate) with a gravity model.

Including other dimensions of transport cost such as roads and rails maintenance or border crossing and extortion costs would provide a more complete picture. However, given the availability of such data, it would dramatically decrease the size of our sample, and would lead to losing the panel dimension. This would prevent us not only from controlling for country-pair specific effects, resulting in consistency problems in the estimates, but also from taking into account the time dimension (1992 to 2004). Then, these costs are assumed as time-invariant in what follows, implying the specific effects of our panel structure capture them.

### 3.2. First set of results: country infrastructure and landlockedness

*Panel specification*

Our approach relies on a panel estimator which covers two dimensions: country pairs and time. We then control for all unobserved bilateral and country-specific characteristics that cannot be included here. Omitting the heterogeneity of these countries or the effects specific to country-pairs in bilateral trade relations may introduce a bias in the estimation of time-invariant variables, such as landlockedness dummies, distance to the nearest port, etc. (see Egger and Pfaffermayr, 2003, Brun et al., 2005, and Carrère, 2006). Due to the unsuitability of a fixed effects model, time effects are modelled as fixed parameters[13] and bilateral effects as random variables[14]. Indeed, the within transformation removes variables, such as

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[13] We use these time dummies as indicators for the spread of "globalization" and to capture common shocks to each country of the world, such as the evolution of oil prices during the given period, or the variable $Y_{Wt}$ of equation (1).

[14] Bilateral effects are specific to each country pair and common to all years. Note that bilateral effects differ according to the direction of trade: $\mu_{ij} \neq \mu_{ji}$.

distance, common borders or landlockedness, which are either bilateral or country-specific, and time-invariant.

*Econometric methods*

If no correlation exists between the explanatory variables and the specific bilateral effects, the Generalized Least Square estimation (GLS) provides consistent estimates of the coefficients. However, variables like GDP or infrastructure may be correlated with bilateral-specific effects. The Hausman test allows us to control for the presence of any correlation between explanatory variables and bilateral-specific effects. [15] The usual way to deal with this issue is to consider an estimation of instrumental variables, as proposed by Hausman and Taylor (1981). The Hausman and Taylor (HT) estimator is based upon an instrumental variable estimator which uses the between and within variation of the strictly exogenous variables, as well as the within variation of the variables correlated with the bilateral-specific effects.

*Data*

The model is estimated with data on 167 countries (see Appendix A.5 for a list of the countries in the sample) over the 1992-2004 period, with trade data from UN COMTRADE (total bilateral imports in current dollars). Data sources for the explanatory variables as well as the data transformations are presented in Appendix A.7. Once the missing values have been removed,[16] 185,967 observations for 23,470 country pairs remain.

*Results*

Results are reported in Table 1. The results from the error-component model (GLS) are reported in the first column. The fit is good ($R^2$=0.66), given that the impact of random specific effects are not in the $R^2$ but are part of the residuals. However, the Hausman test, based on differences between within and GLS estimators, reveals a $\chi^2_{18}$ = 875.72, which is highly significant (1%). Hence, this test rejects the null hypothesis according to which there

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[15] In order to verify $H_0$: when bilateral effects are not correlated with explanatory variables, Hausman (1978) suggests a statistic test based on: $[\beta_{GLS} - \beta_W] . [\text{var}(\beta_{GLS}) - \text{var}(\beta_W)]^{-1} . [\beta_{GLS} - \beta_W]'$. Under the null $H_0$, this test statistic is distributed as a Chi-square ($\chi^2$) with K degrees of freedom (K is the dimension of the vector $\beta_W$ in the within regression, constant excluded).

[16] Countries which do not declare their imports from a partner or which do not import from this partner are identified in the same way, i.e. with a missing value. Hence, our data are not censored at zero.

is no correlation between the bilateral-specific effects and the explanatory variables. Given the bias of the GLS estimator, it is necessary to apply the Hausman and Taylor (HT) method.

| Variables | 1. GLS | 2. HT a) | 3. HT b) | 4. HT a) |
|---|---|---|---|---|
| | | | $M_{ijt}$ | |
| **Ln $Y_{it}$** | 0.852*** | 1.066*** | 0.973*** | 1.078*** |
| | [141.01] | [35.055] | [28.655] | [29.963] |
| **Ln $Y_{jt}$** | 1.069*** | 1.077*** | 0.954*** | 1.168*** |
| | [174.82] | [39.071] | [28.327] | [35.408] |
| **Ln $R_{it}$** | 0.463*** | 0.579*** | 0.409* | 0.503** |
| | [7.21] | [2.648] | [1.753] | [2.206] |
| **Ln $R_{jt}$** | 1.263*** | 0.919*** | 0.722*** | 1.049*** |
| | [19.78] | [4.220] | [3.100] | [4.705] |
| **ln $D_{ij}$** | -1.437*** | -1.507*** | -1.494*** | -1.549*** |
| | [73.51] | [31.846] | [29.335] | [31.946] |
| **$B_{ij}$** | 1.267*** | 0.984*** | 0.844*** | 0.901*** |
| | [12.48] | [4.364] | [3.443] | [3.877] |
| **$L_i$** | -0.246*** | -0.245*** | -0.348*** | -0,105 |
| | [6.98] | [2.658] | [3.493] | [1.046] |
| **$L_j$** | -0.504*** | -0.408*** | -0.527*** | -0.287*** |
| | [14.31] | [4.424] | [5.194] | [2.836] |
| **ln $(1+K_{it})$** | 0.290*** | 0.269*** | 0.287*** | 0.226*** |
| | [13.13] | [6.519] | [6.850] | [4.694] |
| **ln $(1+K_{jt})$** | 0.507*** | 0.204*** | 0.226*** | 0.234*** |
| | [22.87] | [5.043] | [5.517] | [4.991] |
| **ln $N_{it}$** | | | 0.169** | |
| | | | [2.569] | |
| **ln $N_{jt}$** | | | 0.235*** | |
| | | | [3.720] | |
| **ln $RER_{ijt}$** | | | | -0.043*** |
| | | | | [6.443] |
| Number of obs (NT) | 185,967 | 185,967 | 185,967 | 154,871 |
| Number of bilateral (N) | 23,470 | 23,470 | 23,470 | 22,159 |
| R² | 0.659 | | | |
| Hausman test W vs. GLS c) | 875.72*** | - | | |
| *Chi-2(Kw)* | *chi-2 (18)* | | | |
| Hausman test HT vs. GLS d) | - | 143.88*** | | |
| *chi-2(K)* | | *chi-2 (22)* | | |

*** , ** and * significant at the 1%, 5% and 10% level respectively (Absolute values of t-student are presented under the correspondent coefficients).

The time dummy variables and the constant are not reported due to space constraints.

a) Hausman –Taylor method with endogenous variables = $lnY_{it}$, $lnY_{jt}$, $ln(1+K_{it})$ and $(1+lnK_{jt})$

b) Hausman –Taylor method with endogenous variables = $lnY_{it}$, $lnY_{jt}$, $lnN_{it}$, $lnN_{jt}$, $ln(1+K_{it})$ and $(1+lnK_{jt})$

c) This test is applied to the differences between the within and GLS estimators.

d) Hausman test applied to the differences between GLS and HT estimators.

In the second column, the GDP ($Y_{it}$ and $Y_{jt}$) and infrastructure ($K_{it}$ and $K_{jt}$) variables are considered as endogenous. The results show that these variables are correlated with the country pair-specific effects. Indeed, the Hausman test, which compares HT with GLS, validates the hypothesis that the instrumentation improves the model (the hypothesis on the exogeneity of GDP and infrastructure variables is rejected).

Coefficients all have the expected sign and are mostly significant at the 1% level. In line with the theoretical hypotheses (see above), import volumes of i from j increase with GDP, and the coefficients are close to unity. The elasticity of bilateral trade to distance is significantly negative and equals -1.5., while the coefficients for remoteness variables are positive (and significant at the 1% level). This is because the more remote a pair of countries is from the rest of the world, the more they will tend to trade with each other. Countries with a common border trade 2.7 times[17] more than expected by the gravity equation. All these results are similar to the gravity results found in the literature (Limao and Venables, 2001; Brun et al., 2005; Carrère 2006; Soloaga and Winters, 2001).

The coefficients of both infrastructure variables (importer and exporter) have the expected positive sign and are significant at the 1% level, i.e. the volume of trade increases with the level of infrastructure. Moreover, they have a sizeable effect on trade volumes. Moving from the median to the top 25th percentile in the distribution of infrastructure raises import and export volumes by 11.5% and 8.5% respectively. This is equivalent to being 556 km closer to other countries for imports and 426 km for exports.[18] The elasticity of trade to internal infrastructure is lower than reported in Limao and Venables (2001). This is not surprising since we control for bilateral-specific effects and correct for the endogeneity of infrastructure variables. Note, however, that our results are consistent with those of Brun et al. (2005) and Carrère (2006), who applied the same infrastructure indicator, but across a larger sample. They also mirror the findings of Raballand (2003) who applied a similar measure on a smaller sample.[19]

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[17] $2.7 = e^{0.984}$.
[18] Estimates from column 2 which are evaluated at median distance of 8037, so $1.115 = (2.098/1.403)^{(0.269)}$, $1.085 = (2.098/1.403)^{(0.204)}$,
$556.34 = 8037 - 8037 * (1.115^{(-1/1.507)})$ and $425.55 = 8037 - 8037 * (1.085^{(-1/1.507)})$.
The infrastructure quartiles are computed on the average variable for each country in the sample for the 1992-2004 period. See Table 3 below.
[19] We did not find any specific impact of the infrastructure level of individual countries on bilateral trade for landlocked countries in general and Central Asian countries in particular. This is not surprising as the specificity of landlocked country trade is the dependence on overland distance and

The median value of the infrastructure index, $K_{i(j)t}$, is equal to 0.13 for Central Asian countries, while it is equal to 0.26 for other landlocked countries, and to 1.19 for coastal countries in our sample. For Central Asian countries, moving from their median infrastructure indicator to that of other landlocked countries would promote imports and exports by 3.1% and 2.4% respectively.[20] In the same way, moving from their median infrastructure indicator to that of coastal countries would enhance imports by 19.6% and exports by 14.5%.[21]

Finally, we find that landlocked countries are significantly more disadvantaged with regard to trade than coastal countries. According to the predictions of the gravity model, and all other things being equal, a country with no direct sea access imports 22% less and exports 34% less[22] than a coastal country. This estimation is in the same range as others studies (e.g. Carrère, 2006, or Soloaga and Winters, 2001). However, this impact is significantly lower than the impact calculated by Raballand (2003). However, it is difficult to compare results, as Raballand (2003) used a much smaller sample and, most importantly, defined his landlockedness dummy as being equal to 1 for bilateral trade between *two landlocked* countries.[23]

To check the robustness of these findings, we introduced explanatory variables which are often used in empirical literature which apply the gravity model, even if these variables are not formally justified by the gravity derivation used here. In the third column, population variables, $N_i$ and $N_j$, are introduced and are significant at the 5% level (e.g. Bergstrand 1989; Soloaga and Winters, 2001; Brun et al., 2005). The coefficients of the other variables remain unchanged. In the fourth column we introduce the bilateral real exchange rate indices between $i$ and $j$, $RER_{ijt}$ (cf. Soloaga and Winters, 2001, Bayoumi and Eichengreen, 1997, Brun et al., 2005, or Carrère, 2006). The RER is defined as the importing country $i$ currency value

transit infrastructure, but not especially on the returns of their own infrastructure. Hence, Central Asian countries have the same average coefficient for infrastructure as other countries in the sample.
[20] $1.031 = (1.264/1.127)^{(0.269)}$ and $1.024 = (1.264/1.127)^{(0.204)}$.
[21] $1.196 = (2.190/1.127)^{(0.269)}$ and $1.145 = (2.190/1.127)^{(0.204)}$.
[22] $-0.217 = (e^{-0.245} - 1)$ and $-0.335 = (e^{-0.408} - 1)$.
[23] One could expect to observe the impact of landlockedness on Central Asian countries by simply including an interacted variable between the two dummies: landlockedness and Central Asian countries. However, since all these countries are landlocked, we cannot distinguish in this interacted variable between the impact of being landlocked specific to Central Asia and any other constant specific features of this region. However, the definition of alternative variables of landlockedness in the next section will enable us to avoid this shortfall.

of 1 unit of country *j* currency. Consequently, any increase in the RER reflects a depreciation of the importing country's currency against that of the exporting country, which in turn should reduce imports by country i from country j (a negative coefficient is expected). $RER_{ijt}$ is included in the fourth column of Table 1, and the coefficient, significant at the 1% level, has the expected negative sign. Note that the other coefficients remain quite similar after the introduction of the bilateral real exchange rate, except for the landlockedness variables. However, we have controlled for the fact that the lack of precision in the assessment of landlockedness coefficients is due solely to a reduction in sample size (and notably in the number of landlocked countries included in the smaller sample).

### 3.3. Additional specifications for landlockedness in the gravity model

As we have seen in Section 2, landlocked developing countries, and especially Central Asian countries, have a number of conditions which lead to high transport costs and to lower trade levels: they are remote from the major consumer markets where their exports are sold, they depend on land transport, their infrastructure is inadequate to their needs, and they largely depend on transit countries.

In Table 1, once controlled for bilateral distance, remoteness and for the level of infrastructure, landlocked countries are still at a disadvantage in terms of trade. The landlockedness dummy indicates that imports and exports from a country without direct access to the sea are respectively 22% and 34% lower than predicted by the gravity model. The major interest in terms of possible policy recommendations is to improve our understanding of the impact of landlockedness on trade, especially in Central Asia. To this end, we use three alternative measures of the costs of landlockedness.

To better understand the costs of landlockedness on trade, three alternative measures to the landlockedness dummies $L_i$ and $L_j$ are developed. As we are interested in the costs of landlockedness, all three measures are specified, e.g. the greater the variable, the higher the transport costs for the landlocked country and the lower its trade. Due to obvious multicolinearity problems, we *successively* include *other* components of landlockedness.

***Distance to the nearest port***

The first variable to be considered is the distance (by road, in kilometres) between a landlocked import (export) country i (j) and the nearest major port facility, $D_{i(j)}^{PORT}$. This variable captures the additional transport costs from being landlocked due to the extra overland distance that must be travelled in order to reach the sea. This variable is particularly relevant in the case of Central Asia, as already emphasized in Section 2. Indeed, Switzerland and the Czech Republic are 500-600km away from ports like Hamburg or Genoa, whereas Almaty (Kazakhstan) and Bishkek (Kyrgyz Republic) are more than 3,000 km by road from Saint Petersburg and Karachi respectively. In the sample, the shortest distance to port is around 870 km for a median landlocked country, while it is 3,100 km for a median Central Asian country. This is further proof that Central Asian countries are penalized even more than other landlocked countries. Given this substantial difference between Central Asia and other landlocked countries, we will allow for potential non-linearity in the impact of distance to port on Central Asian trade (we include $D_{i(j)}^{PORT}$ both additively and multiplied to a Central Asian dummy).

Hence, the first alternative transport cost function proposed is:

$$\theta_{yt}^{A1} = D_{ij}^{\alpha_1} e^{\alpha_2 B_{ij}} \left(1 + L_i \left(1 - B_{ij}\right) D_i^{PORT}\right)^{\alpha_3} \left(1 + L_j \left(1 - B_{ij}\right) D_j^{PORT}\right)^{\alpha_4} \left(1 + K_{it}\right)^{\alpha_5} \left(1 + K_{jt}\right)^{\alpha_6} \textbf{(3.A1)}$$

with the following expected signs: $\alpha_3 > 0, \alpha_4 > 0$.

The specification implies that a factor of zero is assigned to (i) coastal countries, assuming that the main economic centre is located on the coast, which is the case for many of the countries sampled; and to (ii) trade between neighbour countries (which do not need access to a port).

Results are reported in Table 2. Note that the coefficients of traditional variables ($Y_{i(j)t}$, $R_{i(j)t}$, $D_{ij}$, $K_{i(j)t}$, and $B_{ij}$) remain similar, whatever the specification adopted in columns 5-10.

*Results*

Results in column 5 of Table 2 confirm that the distance between importing countries and major port facilities is a significant impediment to landlocked countries' trade: coefficients for $D_{i(j)}^{PORT}$ are significant at 1% for the exporter, 5% for the importer and have the expected negative signs. As for the landlockedness dummies in Table 2, the impact of $D^{PORT}$ is twice as

high for exports as for imports. For a given landlocked country, all other things being equal, doubling the distance to the nearest maritime port (and then the proportion of overland distance in the total distance) reduces imports by around 3% and exports by around 6%. This implies that, all other things being equal, the median Central Asian country would respectively import and export 4.3% and 8.2% more with a median distance to the nearest port by road, which itself is equivalent to the distance of other landlocked countries to their nearest ports.[24] Of course, this difference is even more important when compared to coastal countries' trade: all other things being equal, Central Asian countries would export (import) around 65% (30%) more had they been median coastal countries.[25] Finally, the results in column 6 do not reveal any non-linearity in the impact of $D_{i(j)}^{PORT}$ on bilateral trade specific to Central Asian countries (the coefficients for the variables multiplied with $CA_{i(j)}$ are non-significantly different from zero).

*Infrastructure of transit countries*

The second defined variable, $K_{i(j)t}^{TRANSIT}$, is the average infrastructure index of the transit countries used by a given landlocked import (export) country i (j). This is reflected in a component of the costs borne by the landlocked countries to reach the sea (Appendix A.6 lists the landlocked countries in this sample as well as their transit countries).[26] As already developed in Section 2, landlocked countries are completely dependent on their transit neighbors' infrastructure to transport their goods to a port. The weak infrastructure of transit countries imposes direct costs on trade passing through them and thus limits the ability of landlocked countries' products to compete in global markets. The relative impact of such weak infrastructure can be all the more severe for Central Asian countries, as they mainly export primary commodities (with low value-to-cost ratios rather than high-value products or services). Hence, as in the previous case, we allow for a potential non-linearity in the impact of a transit country's infrastructure on Central Asian trade (we introduce $K_{it}^{TRANSIT}$ both additively and multiplied to a Central Asian dummy).

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[24] $1.043=(870/3100)^{\wedge}(-0.033)$. and $1.082=(870/3100)^{\wedge}(-0.062)$.
[25] $1.646=(1/3101)^{-0.033}$ and $1.304=(1/3101)^{-0.062}$.
[26] The computation of $K_{it}^{TRANSIT}$ is similar to the one of Limao and Venables (2001). Let $L$ denote a given landlocked country and $L_t$ the set of transit countries that $L$ has to cross to reach the sea. Ideally, the transit countries' infrastructure should be weighted by the share of the considered landlocked country's trade that really uses these transit countries to reach the sea. However, available data on transit countries only report whether a country is used for transit or not. Hence, an equal weight of $1/n$ is given to each of the $n$ transit countries of a landlocked country $L$.

This variable is expected to assess the cost of crossing transit countries to reach the sea, ranging from 0 for coastal economies to a positive value for landlocked countries, where the highest values reflect the highest transit transport costs (and thus the lowest level of infrastructure in the transit country). We then use a transformed measure of this index, so that an *increase* in the variable is expected to be associated with an *increase* in transport costs. [27]

Hence, the second alternative transport costs function proposed is:

$$\theta_{ijt}^{A12} = D_{ij}^{\alpha_1} e^{\alpha_2 B_{ij}} \left( 1 + L_i \left( 1 - B_{ij} \right) \frac{1}{K_{it}^{Transit}} \right)^{\alpha_3} \left( 1 + L_j \left( 1 - B_{ij} \right) \frac{1}{K_{jt}^{Transit}} \right)^{\alpha_4} \left( 1 + K_{it} \right)^{\alpha_5} \left( 1 + K_{jt} \right)^{\alpha_6} \textbf{(3.A2)}$$

with the following expected signs: $\alpha_3 > 0, \alpha_4 > 0$ .

As previously mentioned, the specification implies that a factor of zero is assigned to coastal countries or to landlocked countries trading with a neighbour to reflect correctly that this trade does not bear any extra infrastructure-related transit transport costs.

*Results*

The average level of transit countries' infrastructure, $K_{i(j)t}^{TRANSIT}$ , is included in column 7 of Table 2. The coefficients have expected negative signs but only the coefficients for the exporter are significantly different from zero: high values of $K_{i(j)t}^{TRANSIT}$, reflecting large transit transport costs (due to weak transit infrastructure in the transit countries) significantly hamper exports of landlocked countries. Note that internal infrastructure effects continue to be highly significant.

Central Asian trade, both in terms of exports and imports (see column 8), is particularly sensitive to the level of infrastructure in the transit countries: the coefficients associated with $CA_{i(j)}$ are significant at the 1% level and highly negative. The transit countries for Central Asian trade have a median infrastructure index equal to 0.11, while the median level of the transit countries infrastructure index for non Central Asian landlocked countries is 0.60. Results in column 8 imply that if central Asian countries had access to transit countries'

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[27] There is a caveat. We assume here that no trade (or the same share of trade for all countries) goes by air. Although this is clearly unrealistic and the share of trade that is airborne is rising, it is still small enough for landlocked countries (and Central Asian countries) to justify such an assumption. Moreover, the transport costs from landlocked countries to their neighbouring countries should not include transit country costs. For this reason, our variable is adjusted to reflect this fact when necessary.

infrastructure which is similar to that of the others landlocked countries, their imports would increase by 14.6% and their exports by 44.8%.[28]

*Number of borders shared with coastal countries*

A third measure analyses the ability of a landlocked country to negotiate sea access at the lowest cost. $B_{i(j)}{}^{\text{TRANSIT}}$ relies on the number of borders it shares with coastal countries and is expected to capture the transit costs: the greater the number of coastal neighbours, the lower the transit costs. It is critical for a coastal country to attract transit trade flows from landlocked states. If a monopoly exists, the landlocked country has no bargaining power, which in turn has a negative impact on trade. A decrease of 1 in the indicator corresponds to an additional coastal neighbour that could strengthen the competition between the potential transit countries and weaken the bargaining power of each transit country, resulting in a decrease in the costs borne by the landlocked country. Again, this variable is particularly relevant for Central Asian countries. For instance, Kazakhstan has only two coastal countries to bargain with. Moreover, Turkmenistan, Tajikistan and Kyrgyzstan can only rely on one neighbouring country with direct sea access to develop their trade beyond its borders. Finally, Uzbekistan is the only example of a doubly landlocked[29] country in our sample (the only other example is Liechtenstein which is not included here). For instance, the other landlocked countries in our sample can choose between (minimum) 2 to (maximum) 5 neighboring countries to reach a maritime port. With this variable, we want to measure the monopoly power of transit countries, ranging from 0 for coastal economies to a positive value for landlocked countries, with highest values reflecting the highest costs (due to the perfect monopoly position of the transit country). In other words, the more neighboring countries with sea access which a landlocked country has, the easier it is to boost competition between these countries and subsequently to lower transit costs. An increase in the number of neighbouring countries with sea access is reflected in lower transit costs, where the $B_{i(j)}{}^{\text{TRANSIT}}$ variable decreases with the number of coastal neighbours. Once again we introduce $B_{i(j)}{}^{\text{TRANSIT}}$ both additively and multiplied to a Central Asian dummy.

Hence, the third alternative transport costs function proposed is:

$$\theta_{ijt}^{A3} = D_{ij}^{\alpha_2} e^{\alpha_2 B_{ij} + \alpha_3 L_i \left(1 - B_{ij}\right) B_i^{\text{Transit}} + \alpha_4 L_j \left(1 - B_{ij}\right) B_j^{\text{Transit}}} \left(1 + K_{it}\right)^{\alpha_5} \left(1 + K_{jt}\right)^{\alpha_6} \qquad (3.A3)$$

With the following expected signs: $\alpha_3 > 0, \alpha_4 > 0$.

---

[28] $1.146 = ((1+1/0.6)/ (1+1/0.108))^{\wedge}(-0.101)$ and
  $1.448 = ((1+1/0.6)/ (1+1/0.108))^{\wedge}(-0.083-0.194)$.
[29] I.e. only surrounded by landlocked countries.

*Results*

Column 9 confirms that a landlocked country's trade decreases as the monopoly power of transit countries increases (based on the number of options a landlocked country has to reach a port). Coefficients associated with $B_i$ TRANSIT and $B_j$ TRANSIT have significant and expected negative signs: a decrease of 1 in this indicator (reflecting increased competition between transit countries as well as greater bargaining power for the landlocked country) implies an increase of 6.2% in the imports and of 8.2% in the exports of the given landlocked country.[30] This result is all the more pertinent for Central Asian countries. Indeed, the median indicator for Central Asian countries is 5, corresponding to only one coastal neighbour. In other words, these countries have to cope with a situation where the transit country has monopoly power. All other things being equal, this implies that these countries would import 10.1% more if they were in the same situation as a coastal country (i.e. without a transit country) and export 49.2% more. [31] Results in column 10 do not reveal any non-linearity in the impact of $B_{i(j)}$ TRANSIT on bilateral trade which is specific to Central Asian countries (the coefficients for the variables multiplied with $CA_{i(j)}$ are non-significantly different from zero).

To summarize, if we note the equation (4) as:

$$\ln M_{ijt} = \beta_0 + \beta_1 \ln Y_{it} + \beta_2 \ln Y_{jt} + \beta_3 \ln R_{it} + \beta_4 \ln R_{jt} + \beta_5 \ln D_{ij}$$
$$+ \beta_6 B_{ij} + \beta_7 L_i + \beta_8 L_j + \beta_9 \ln(1 + K_{it}) + \beta_{10} \ln(1 + K_{jt}) + \omega_{ijt}$$
$$= \Omega X + \beta_7 L_i + \beta_8 L_j$$

The three alternative gravity models estimated are:

$$\begin{cases} \ln M_{ijt} = \Omega X + \beta_7 \ln\left(1 + L_i\left(1 - B_{ij}\right)D_i^{PORT}\right) + \beta_8 \ln\left(1 + L_j\left(1 - B_{ij}\right)D_j^{PORT}\right) \\ \ln M_{ijt} = \Omega X + \beta_7 \ln\left(1 + L_i\left(1 - B_{ij}\right)\dfrac{1}{K_{it}^{Transit}}\right) + \beta_8 \ln\left(1 + L_j\left(1 - B_{ij}\right)\dfrac{1}{K_{jt}^{Transit}}\right) \\ \ln M_{ijt} = \Omega X + \beta_7 L_i\left(1 - B_{ij}\right)B_i^{Transit} + \beta_8 L_j\left(1 - B_{ij}\right)B_j^{Transit} \end{cases}$$

With the expected signs: $\beta_7 = (1-\sigma)\alpha_3 < 0$ and $\beta_8 = (1-\sigma)\alpha_4 < 0$.

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[30] 0.062=(e^{-0.060*-1}-1) and 0.082=(e^{-0.079*-1}-1).

[31] 1.101=(e^{-0.060*-5}-1) and 1.492=(e^{-0.079*-5}-1).

**Table 2: Results of the gravity equation estimates on panel data**

| Variables | $M_{ijt}$ | | | | | |
|---|---|---|---|---|---|---|
| | **5. HT** | **6. HT** | **7. HT** | **8. HT** | **9. HT** | **10. HT** |
| **Ln $Y_{it}$** | 1.068*** | 1.068*** | 1.079*** | 1.081*** | 1.067*** | 1.066*** |
| | [35.131] | [35.151] | [42.440] | [41.770] | [35.123] | [35.083] |
| **Ln $Y_{jt}$** | 1.077*** | 1.077*** | 1.099*** | 1.101*** | 1.085*** | 1.085*** |
| | [39.018] | [39.013] | [47.193] | [46.390] | [39.511] | [39.501] |
| **Ln $R_{it}$** | 0.584*** | 0.620*** | 0.598*** | 0.563*** | 0.585*** | 0.619*** |
| | [2.675] | [2.831] | [2.787] | [2.600] | [2.672] | [2.817] |
| **Ln $R_{jt}$** | 0.920*** | 0.959*** | 1.027*** | 0.996*** | 0.941*** | 0.980*** |
| | [4.230] | [4.386] | [4.844] | [4.643] | [4.312] | [4.475] |
| **ln $D_{ij}$** | -1.506*** | -1.511*** | -1.500*** | -1.498*** | -1.503*** | -1.509*** |
| | [31.829] | [31.900] | [31.495] | [31.419] | [31.688] | [31.790] |
| **$B_{ij}$** | 0.986*** | 0.984*** | 0.924*** | 0.797*** | 0.959*** | 0.954*** |
| | [4.374] | [4.369] | [4.063] | [3.468] | [4.244] | [4.227] |
| **ln $(1+K_{it})$** | 0.269*** | 0.269*** | 0.284*** | 0.283*** | 0.270*** | 0.271*** |
| | [6.509] | [6.523] | [5.359] | [6.892] | [6.535] | [6.566] |
| **ln $(1+K_{jt})$** | 0.204*** | 0.204*** | 0.216*** | 0.216*** | 0.206*** | 0.206*** |
| | [5.021] | [5.026] | [6.927] | [5.347] | [5.072] | [5.091] |
| **$CA_i$** | | 2,999 | | 2.257*** | | -0,119 |
| | | [0.522] | | [2.718] | | [0.082] |
| **$CA_j$** | | -4,620 | | 2.201*** | | 2,279 |
| | | [0.845] | | [2.679] | | [1.589] |
| *Landlocked components:* | | | | | | |
| 1. Distance to the nearest port | | | | | | |
| **ln $(1+L_i(1-B_{ij})D_i^{PORT})$** | -0.033** | -0.042*** | | | | |
| | [2.421] | [2.963] | | | | |
| **ln $(1+L_j(1-B_{ij})D_j^{PORT})$** | -0.062*** | -0.073*** | | | | |
| | [4.552] | [5.143] | | | | |
| **$CA_i$. ln $(1+L_i(1-B_{ij})D_i^{PORT})$** | | -0,032 | | | | |
| | | [0.446] | | | | |
| **$CA_j$. ln $(1+L_j(1-B_{ij})D_j^{PORT})$** | | 0,064 | | | | |
| | | [0.937] | | | | |
| 2. Infrastructure of transit countries | | | | | | |
| **ln $(1+L_i(1-B_{ij})/K_{it}^{TRANSIT})$** | | | -0,029 | -0,034 | | |
| | | | [1.246] | [1.416] | | |
| **ln $(1+L_j(1-B_{ij})/K_{jt}^{TRANSIT})$** | | | -0.083*** | -0.082*** | | |
| | | | [3.494] | [3.482] | | |
| **$CA_i$. ln $(1+L_i(1-B_{ij})/K_{it}^{TRANSIT})$** | | | | -0.101*** | | |
| | | | | [2.802] | | |
| **$CA_j$. ln $(1+L_j(1-B_{ij})/K_{jt}^{TRANSIT})$** | | | | -0.194*** | | |
| | | | | [2.614] | | |
| 3. No. of borders with coastal countries | | | | | | |
| **$L_i(1-B_{ij})B_i^{TRANSIT}$** | | | | | -0.060** | -0.093*** |
| | | | | | [2.219] | [3.084] |
| **$L_j(1-B_{ij})B_j^{TRANSIT}$** | | | | | -0.079*** | -0.105*** |
| | | | | | [2.969] | [3.535] |
| **$CA_i$. $L_i(1-B_{ij})B_i^{TRANSIT}$** | | | | | | 0,139 |
| | | | | | | [0.470] |
| **$CA_j$. $L_j(1-B_{ij})B_j^{TRANSIT}$** | | | | | | -0,366 |
| | | | | | | [1.262] |
| Number of obs (NT) | 185967 | 185967 | 185967 | 185967 | 185967 | 185967 |
| Number of bilateral (N) | 23470 | 23470 | 23470 | 23470 | 23470 | 23470 |

\*\*\*, \*\* and \* significant at the 1%, 5% and 10% levels respectively (Absolute value of t-student is presented under the correspondent coefficient). The time dummy variables and the constant are not reported in order to save space.
$CA_{i(j)}$ =1 if country i(j) is a Central Asian countries.
Hausman –Taylor method with endogenous variables = lnYit, lnYjt, ln(1+Kit) and (1+lnKjt ).

**4. IMPLICATIONS FOR CENTRAL ASIAN COUNTRIES: SUMMARY OF THE MAIN RESULTS**

Table 3 reports the quartile values for our variables of interest, while Table 4 summarizes the disadvantages of being landlocked and having a weak infrastructure for a representative (i.e. median) Central Asian country.

**Table 3: Quartile values (computed on average between 1992 and 2004)**

| | | Percentile | | | |
|---|---|---|---|---|---|
| | | 25th | Median | 75th | obs. |
| $K$ | Total sample | 0.072 | 0.403 | 1.098 | 167 |
| | Coastal countries | 0.091 | 1.190 | 1.996 | 132 |
| | CA countries | 0.064 | 0.127 | 0.168 | 5 |
| | Other landlocked countries | 0.031 | 0.264 | 0.533 | 30 |
| $K^{TRANSIT}$ | CA countries | 0.108 | 0.108 | 0.119 | 5 |
| | Other landlocked countries | 0.064 | 0.600 | 0.801 | 30 |
| $D^{PORT}$ | CA countries | 2950 | 3100 | 3600 | 5 |
| | Other landlocked countries | 597.5 | 870 | 1206 | 30 |
| $B^{TRANSIT}$ | CA countries | 5 | 5 | 5 | 5 |
| | Other landlocked countries | 2 | 3 | 4 | 30 |

Note: CA= Central Asian.
*Source: Authors' calculations.*

We compute how the volume of trade of this median Central Asian country will change depending on the levels of its own and/or of its transit countries' infrastructure, on the extra transport costs due to overland transport distances and on the ability of a landlocked country to negotiate access to the sea.

**Table 4: Simulations of trade changes for a median Central Asian country**

| | Percentile across landlocked countries (excl. Central Asia) | | | Coastal countries |
|---|---|---|---|---|
| | 25th | Median | 75th | Median |
| **Exports** | | | | |
| K | -1.8% | 2.4% | 6.5% | 14.5% |
| K$^{TRANSIT}$ | -12.7% | 44.8% | 51.8% | 89.7% |
| D$_I^{PORT}$ | 10.8% | 8.2% | 6.0% | 64.6% |
| B$^{TRANSIT}$ | 27.1% | 17.4% | 8.3% | 49.2% |
| **Imports** | | | | |
| K | -2.4% | 3.1% | 8.6% | 19.6% |
| K$^{TRANSIT}$ | -4.9% | 14.6% | 16.6% | 26.5% |
| D$_I^{PORT}$ | 5.6% | 4.3% | 3.2% | 30.4% |
| B$^{TRANSIT}$ | 5.7% | 3.1% | 1.3% | 10.1% |

*Source: Authors' calculations.*

Note: The construction of the trade changes reported in the above table is as follows. We first calculate the predicted trade for a median Central Asian country (on average over 1992-2004), denoted $M_{CA}$. We then compute the predicted trade, denoted $M_{pred}$ allowing K, K$^{TRANSIT}$, D$_I^{PORT}$, and B$^{TRANSIT}$ to vary *successively*, while keeping all other variables at the level of the representative Central Asian country (median value). The change reported in the table is $100(M_{pred}/M_{CA} -1)$. The values of K, K$^{TRANSIT}$, D$_I^{PORT}$, and B$^{TRANSIT}$ chosen for the simulations are the quartile values across the landlocked countries (excluding Central Asia) and the median value across coastal countries. All the explanatory variable values used in these calculations are reported in Table 3. The gravity specifications are found in column 2 of Table 3 and columns 6, 8 and 10 of Tables 1 and 2.

To summarize, an improvement in the internal infrastructure of each Central Asian country from the level of the median Central Asia country to that of the best 25th percentile of other landlocked countries increases exports and imports by 6.5% and 8.6% respectively.[32] An improvement in K to the level of the median coastal country generates an increase in exports and imports of 14.5% and 19.6% respectively. The impact of the infrastructure of an individual country is not particularly significant[33] but it would appear that the infrastructure of transit countries is of greater importance for the international trade of landlocked countries. This hypothesis is confirmed by the results presented in this Section. An improvement in transit country infrastructure to the level of the best 25th percentile of other landlocked countries, by cutting transit transport costs, increases the representative

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[32] Maintaining all other variables at the level of the representative Central Asian country (median value).

[33] Not specific to landlocked countries, as the associated coefficient is the same for all countries in the sample.

Central Asian exports flow by 52%. Where all transit transport costs are removed, as for a median costal country, representative Central Asian export flows would be increased by 90%.

Other dimensions of landlockedness are also great impediments to the trade of Central Asian countries. Hence, diminishing the extra overland costs (proxied by the distance to the nearest port) or enhancing the ability of a landlocked country to negotiate sea access compared to others landlocked countries would significantly increase Central Asian trade.

## 5. CONCLUSION

The empirical evidence reviewed in this paper suggests that building roads is probably not by itself the best way of alleviating the burden of landlockedness. We find that three factors really matter, none of which is directly linked to the landlocked CACs' own infrastructure: overland transportation costs, bargaining power with transit countries and the infrastructure of the latter. Moreover, of the three components of trade costs arising from landlockedness, only the transit countries' infrastructure is specific to Central Asia. Improvements in transit- country infrastructure raise trade three times more for Central Asian countries than for other landlocked countries. By contrast, distance to port and the number of coastal neighbours a proxy for competition between transit corridors have the same impact for Central Asian countries and for other landlocked countries.

Besides the usual caveats, our results highlight the need to pursue a double policy agenda. First, transit corridors are regional public goods and should be managed as such through international cooperation. International financial institutions can, and do, play a key role in this regard by providing assistance and coordination, as well as participating in policy dialogue. Second, Central Asian countries should actively seek diversification of their transit corridors to prevent the creation or maintenance of monopoly positions in transit and bottleneck points such as trans-shipment platforms. In particular, the progressive shift in Central Asian trade toward China should be accompanied by the strategic development of new transit corridors.

Further work is needed to include more explicit corruption variables in the analysis[34]. If not specific to landlocked countries, corruption is likely to represent significant

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[34] Extortion costs are likely to be collinear with overland transportation costs if roadblocks are scattered at random along roads. Moreover, focusing on landlocked countries, the greater the number of coastal

trade costs through extortion and border crossing costs (see Olken and Barron 2007 on the Indonesian case). The problem would be to collect enough data to test it on a large panel of countries.

From a policy perspective, the large inhibiting effect of landlockedness and poor transit infrastructure also matters because it reduces the return to trade-policy reform. Once transit bottlenecks are removed, in the logic of Friedman and Johnson (1997) policy reform complementarities can set in, reform in one area raising the return to reform in others.

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countries, the bigger the bargaining power with the transit countries and the lesser the border crossing costs. Last, assuming these costs are time-invariant, they are controlled for by the panel structure of our empirical analysis.

# REFERENCES

Anderson, J.E., Van Wincoop, E., 2004. "Trade Costs". *Journal of Economic Literature*. Vol. XLII (September): 691–751.

Anderson, J.E., Van Wincoop, E., 2003. "Gravity with Gravitas: A Solution to the Border Puzzle." *American Economic Review*, 93: 170-192.

Asian Development Bank, 2006, Central Asia: increasing gains from trade through regional cooperation in trade policy, transport and customs transit, 94 pages.

Babetskaia-Kukharchuk, O. and Maurel, M., 2004, "Russia's accession to the WTO: What potential for trade increase", *Journal of Comparative Economics*, 32: 680–699.

Baier, S.L and Bergstrand, J.H., 2002, "On the Endogeneity of International Trade Flows and Free Trade Agreements", American Economic Association annual meeting.

Baldwin, R., 1994. *Towards an Integrated Europe*, London: Centre for Economic Policy Research.

Bayoumi, T. and Eichengreen, B., 1997, "Is Regionalism Simply a Diversion? Evidence from the Evolution of the EC and EFTA" In *Regionalism versus Multilateral Trade Arrangements*, ed. Ito, T., and Krueger, A., NBER-ease, University of Chicago Press, Vol.6, Chap.6.

Bergstrand, Jeffrey H., 1989, "The Generalized Gravity Equation, Monopolistic Competition, and the Factor-Proportions Theory in International Trade," *Review of Economics and Statistics*, 71(1), February: 143-53.

Bevan, A.A., S. Estrin, and K. Meyer. (2001) "Institution Building and the Integration of Eastern Europe in International Production." *Center for New and Emerging Markets Discussion Paper No.11, London Business School.*

Bougheas S., Demetriades P.O. and E.L. Morgenroth, 1999, "Infrastructure, transport costs and trade", *Journal of International Economic*, vol. 47(1): 169-189.

Brun, J.F., Carrere, C., Guillaumont, P. and Melo, J. de, 2005, "Has Distance Died? Evidence from a Panel Gravity Model", the *World Bank Economic Review*, Vol. 19(1): 99-120.

Cadot, O., Dutoit, L. and J. de Melo, 2005, The Elimination of Madagascar's Vanilla Marketing Board, Ten Years On, CEPR. Available at:
www.cepr.org/pubs/dps/DP5548.asp

Cadot. O, Dutoit, L. and M.Olarreaga, 2005, How Costly is it for Poor Farmers to Lift Themselves Out of Poverty? CEPR discussion paper 5392.

Carcamo-Diaz R., Towards development in landlocked countries. Cepal Serie macroeconomia del desarrollo No. 29. Santiago, 2004.

Carrère, C., 2006, "Revisiting the effects of regional trade agreements on trade flows with proper specification of the gravity model", *European Economic Review*, Vol. 50/2: 223-247.

Deardorff, A., 1998, "Determinants of Bilateral Trade : Does Gravity Work in a Neoclassical World?", in *The Regionalization of the World Economy*, Eds. Frankel, J.A., University of Chicago Press.

Dion, R., 2000, The decline of Central Asian integration, Central Asia Caucasus Analyst Biweekly Briefing, John Hopkins University, Baltimore, MD.

Djankov, S.and Freund, C., 2002, "Trade flows in the former Soviet Union, 1987 to 1996", *Journal of Comparative Economics*, 30: 76–90.

Egger, P. and Pfaffermayr, M., 2003, "The Proper Panel Econometric Specification for the Gravity Equation: A Three-way Model with Bilateral Interaction Effects". *Empirical Economics*; 28 (3): 571-580.

Estache A. and A. Goicoechea, 2005, A Research Database on Infrastructure Economic Performance, World Bank Policy Research Working Paper 3643, 2005.

Evenett S. and Keller W., 1998, "On Theories explaining the Success of the Gravity Equation", *NBER Working Paper* No. 6529 (Cambridge, Massachusetts : National Bureau of Economic Research).

Faye M.L., McArthur J.W., Sachs J.D. and Snow T., 2004, The Challenges Facing Landlocked Developing Countries, Journal *of Human Development*, Vol. 5, No. 1, March 2004: 31-68.

Feenstra, R., 2004, *Advanced International Trade: Theory and Evidence*, Princeton University Press, Chap.5.

Fidrmuc J. and Fidrmuc J., 2003, "Disintegration and trade", *Review of International Economics*, Blackwell Publishing, Vol. 11(5): 811-829.

Gallup, J. L., Sachs J. D., and Mellinger A. D, 1998, Geography and Economic Development. NBER Working Paper No. W6849. Available at SSRN: http://ssrn.com/abstract=145013

Grafe, C., Raiser, M., Sakatsume, T., 2005, "The importance of good neighbors: regional trade in Central Asia", in: Auty, R.M., (Ed.), Lessons not learned: natural resource rent and social welfare in the CCA Countries. Routledge-Curzon, London, in press.

Hamilton, C. and L.A. Winters, 1992, "Opening up international trade in Eastern Europe", *Economic Policy* **14**: 77–116.

Hausman, J.A. and Taylor, E., 1981, "Panel data and unobservable individual effects", *Econometrica*, 49: 1377-1398.

Havrylishin, O. and Al-Atrash, H., 1998, "Opening up and geographic diversification of trade in transition economies", IMF Working Paper 98/22.

Helliwell, J. F., 1998, *How Much Do National Borders Matter?* (Washington: Brookings Institution).

Hummels, D., 2001, "Time as a Trade Barrier", mimeo, Purdue University, July.

Kaminski, B.,Wang, Z.K.,Winters, L.A., 1996, "Export performance in transition economies", *Economic Policy* **23**: 423–442.

Limao, N. and Venables, A.J., 2001, "Infrastructure,Geographical Disadvantage and Transport Costs", *World Bank Economic Review*, 15: 451-479.

Mc Callum, J. , 1995, National Borders Matters: Canada-US Regional Trade Patterns', American Economic Review, Vol. 85, No. 3: 615-623.

Ojala M., 2005, Review of inter-regional trade and transport facilitation in Europe and Central Asia region, South Asia region East Asia and Pacific region, third draft, 62 pages.

Ojala, L., Naula, T. and Queiroz, C., 2004, Transport Sector Restructuring in the Baltic States Toward EU Accession, the World Bank, Turku, available at:http://wbln0018.worldbank.org/ECA/Transport.nsf/0/5FC55219E4D31FC68525 6E76005E27B4?Opendocument

Olken Benjamin A. and Patrick Barron, 2007, The Simple Economics of Extortion: Evidence from Trucking in Aceh, BREAD Working Paper No. 151

Pomfret, R., 2005, Trade Policies in Central Asia after EU Enlargement and before Russian WTO Accession, *Economic Systems*, 29(1), March: 32-58.

Raballand, G., 2003, " Determinants of the negative impact of being landlocked on trade: an empirical investigation through the Central Asian case", *Comparative Economic Studies* **45**: 520–536.

Raballand, G., Kunth, A. and Auty R., 2005, "Central Asia's transport cost burden and its impact on trade", *Economic Systems* **29**: 6–31.

Radelet, S. and JD. Sachs, 1999, Shipping costs, manufactured exports, and Economic Growth. Mimeo. HIID, Cambridge, MA.

Satubaldin S. and Zhandaulet T., 2002, Investsionnyi Potentsial Regiona: Metodicheskie Aspkety Otsenki I Mekhanizm Ispolzovaniia. KIMEP, Almaty.

Stone, JI., 2001, "Infrastructure development in landlocked and transit developing countries: Foreign aid private investment and the transport cost burden of landlocked developing countries", UNCTAD/LDC/II2, UNCTAD, Geneva.

Soloaga, I. and Winters, A., 2001, "How Has Regionalism in the 1990s Affected Trade?", *North American Journal of Economics and Finance*, 12:1-29.

UNCTAD, 2004, Design and implementation of transit transport arrangements, TD/B/COM.3/EM.22/2.

UNESCAP 2003 "Transit Transport Issues in Landlocked and Transit Developing Countries", United Nations, New York.

World Bank 2004a Trade and Transport Facilitation in Central Asia: Reducing the Economic Distance to Markets, mimeo.

World Bank  2004b Trade and Regional Cooperation between Afghanistan and its Neighbors, Report No. 26769.

World Bank, 2005, From Disintegration to Reintegration, Eastern Europe and the former Soviet Union in International Trade, ED. H.G. Broadman, The World Bank.

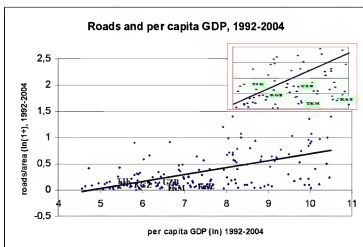## A.1. Transit links of Central Asian Republics with world markets



*Source: World Bank 2004a*

## A.2. Infrastructure and per capita GDP, 1992-2004[35]
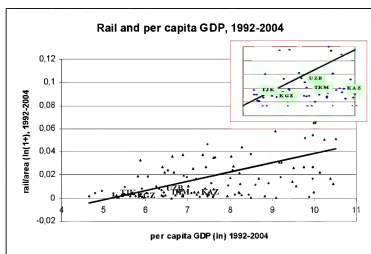
### Figure 1. Road density and per capita GDP, 1992-2004



Source: authors' calculations
Note: A sample of 173 countries; OLS regression line shown on graph. Box highlights OLS regression line for Central Asia

### Figure 2. Railroad density and per capita GDP, 1992-2004



Source: authors' calculations
Note: A sample of 125 countries; OLS regression line shown on graph. Box highlights OLS regression line for Central Asia

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[35] The graphs are scatter plots of road and rail network densities against GDP per capita for a large sample of countries over roughly a decade. The lines are Ordinary Least Squares (OLS) fitted lines and indicate the predicted level of infrastructure density as a function of GDP per capita. Countries above the line have densities above that predicted by their income levels, and conversely. The graphs clearly show that four out of five Central Asian republics (excluding Tajikistan) have infrastructure densities below that predicted by their level of per capita GDP.[35]

**A.3. Comparison of selected border-crossing costs (US dollars per TEU[36])**
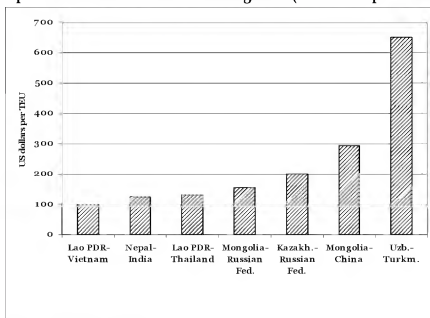


*Source: UNESCAP 2003*

**A.4. Comparison of selected border crossing times (hours)**
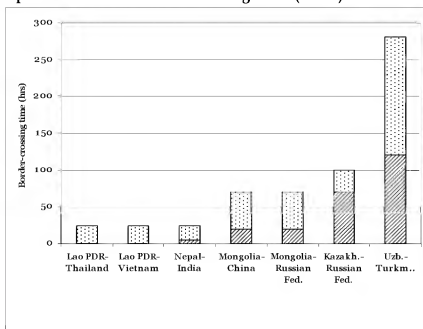


*Source: UNESCAP 2003*

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[36] * TEU stands for 'twenty-foot equivalent unit', and is used to express the relative number of containers based on the equivalent length of a 20' container.

## A.5. Countries in the sample.

Albania; Algeria; Angola; Argentina; Armenia; Australia; Austria; Azerbaijan; Bahamas; Bahrain; Bangladesh; Barbados; Belarus; Belgium; Belize; Benin; Bhutan; Bolivia; Bosnia and Herzegovina; Botswana; Brazil; Bulgaria; Burkina Faso; Burundi; Cambodia; Cameroon; Canada; Cape Verde; Central African Republic; Chad; Chile; China; Colombia; Comoros; Congo Rep.; Costa Rica; Côte d'Ivoire; Croatia; Cyprus; Czech Republic; Denmark; Djibouti; Dominica; Dominican Republic; Ecuador; Egypt Arab Rep.; El Salvador; Eritrea; Estonia; Ethiopia; Fiji; Finland; France; Gabon; Gambia; Georgia; Germany; Ghana; Greece; Grenada; Guatemala; Guinea; Guinea-Bissau; Guyana; Haiti; Honduras; Hong-Kong; Hungary; Iceland; India; Indonesia; Iran Islamic Rep.; Ireland; Israel; Italy; Jamaica; Japan; Jordan; Kazakhstan; Kenya; Korea Rep.; Kuwait; Kyrgyz Republic; Lao PDR; Latvia; Lebanon; Lesotho; Liberia; Libya; Lithuania; Luxembourg; Macao; Macedonia; Madagascar; Malawi; Malaysia; Mali; Malta; Mauritania; Mauritius; Mexico; Micronesia Fed. Sts.; Moldova; Mongolia; Morocco; Mozambique; Namibia; Nepal; Netherlands; New Zealand; Nicaragua; Niger; Nigeria; Norway; Oman; Pakistan; Panama; Papua New Guinea; Paraguay; Peru; Philippines; Poland; Portugal; Romania; Russian Federation; Rwanda; Sao Tome and Principe; Saudi Arabia; Senegal; Seychelles; Sierra Leone; Singapore; Slovak Republic; Slovenia; Solomon Islands; South Africa; Spain; Sri Lanka; Sudan; Suriname; Swaziland; Sweden; Switzerland; Syrian Arab Republic; Tajikistan; Tanzania; Thailand; Togo; Tonga; Trinidad and Tobago; Tunisia; Turkey; Turkmenistan; Uganda; Ukraine; United Arab Emirates; United Kingdom; United States; Uruguay; Uzbekistan; Samoa; St. Kitts and Nevis; St. Lucia; St. Vincent and the Grenadines; Vanuatu; Venezuela; Vietnam; Yemen Rep.; Zambia; Zimbabwe.

## A.6. Landlocked and transit countries.

| Landlocked Countries | Transit Countries |
| --- | --- |
| Afghanistan | Iran, Pakistan |
| Armenia | Azerbaijan, Georgia, Russia, Turkey |
| Austria | Germany, Italy |
| Azerbaijan | Georgia, Russia |
| Bhutan | Bangladesh, India |
| Bolivia | Argentina, Brazil, Chile, Peru |
| Botswana | Namibia, South Africa |
| Burkina-Faso | Côte d'Ivoire, Togo |
| Burundi | Kenya, Tanzania, Uganda |
| Central African Rep. | Cameroon, Congo Rep., Congo Dem. Rep. |
| Chad | Cameroon, Nigeria |
| Czech Rep. | Belgium, Germany, Netherlands |
| Ethiopia | Djibouti, Kenya, Somalia |
| Hungary | Austria, Italy |
| Kazakhstan | Afghanistan, Iran, Kyrgyz Rep., Pakistan, Russia, Turkmenistan, Uzbekistan |
| Kyrgyz Rep. | Afghanistan, Iran, Kazakhstan, Pakistan, Russia, Turkmenistan, Uzbekistan |
| Laos | Thailand, Vietnam |
| Lesotho | South Africa |
| Luxembourg | Belgium, France, Germany |
| Malawi | Botswana, Mozambique, Zambia, Zimbabwe |
| Mali | Burkina-Faso, Côte d'Ivoire, Senegal |
| Macedonia | Albania, Greece |
| Mongolia | China, Russia |
| Nepal | Bangladesh, India |
| Niger | Benin, Burkina-Faso, Nigeria, Togo |
| Paraguay | Argentina, Brazil, Chile, Uruguay |
| Rwanda | Burundi, Kenya, Tanzania, Uganda |
| Slovak Rep. | Czech Rep., Germany, Poland |
| Swaziland | Mozambique, South Africa |
| Switzerland | Germany, Italy, Netherlands |
| Tajikistan | Afghanistan, Kyrgyz Rep., Pakistan, Uzbekistan |
| Turkmenistan | Afghanistan, Iran, Pakistan, Russia |
| Uganda | Kenya, Tanzania |
| Uzbekistan | Afghanistan, Kazakhstan, Pakistan, Russia |
| Zambia | Mozambique, South Africa, Tanzania |
| Zimbabwe | Mozambique, South Africa, Tanzania |

*Source: Limao and Venables (2001) and UNCTAD (2004)*

## A.7: Data sources and definitions of the variables

$M_{ijt}$: Total bilateral imports, in current US$, by country $i$ from country $j$ at date $t$, UN-COMTRADE. The original database does not contain any zero.

$Y_{i(j)t}$: GDP of country $i$ ($j$) at date $t$, in constant US$ 2000, CD-ROM WDI, World Bank 2005.

$N_{i(j)t}$: Total population of country $i$ ($j$) at date $t$, CD-ROM WDI, World Bank 2005.

$D_{ij}$: Distance measured in kilometres between the main city in country $i$ and the main city in country $j$. Most of the time, the main city is the capital city, but for some countries the main economic city is considered. Data on distance are taken from the CEPII. http://www.cepii.fr/anglaisgraph/bdd/distances.htm

$B_{ij}$: Dummy equal to one if $i$ and $j$ share a common land border, 0 otherwise.

$L_{i(j)}$: Dummy equal to one if i (j) is a landlocked country, 0 otherwise.

$K_{i(j)t}$: Infrastructure index based on Limao and Venables (2001) and built using four variables proxying the infrastructure from the World Development Indicators (WB, 2005): number of kilometres of roads, of paved roads, of railways, and number of telephone sets/lines per capita. The first three variables are in ratio to the surface area (WB, 2005) in order to obtain the density value. Each variable, thus obtained, is normalized to have a mean equal to one. An arithmetic average is then calculated over the four variables. It has been checked that these data from the World Development Indicators are consistent with the data from Antonio Estache and Ana Goicoechea "A "Research" Database on Infrastructure Economic Performance World Bank Policy Research Working Paper 3643, June 2005.


$RER_{ijt}$: Bilateral real exchange rate (RER) is computed as follow:

$RER_{ijt} = (CPI_{jt})/(CPI_{it}).(NER_{it/\$t}/NER_{jt/\$t})$,

Where $NER_{i(j)t/\$t}$ is the country $i$ ($j$)'s currency value for one US$ at date $t$ and $CPI_{i(j)t}$ the consumption price index for country $i$ ($j$) at date $t$. Data are taken from the IFS database. If the CPI is not available, the GDP deflator is used instead. For each pair of countries, we specify the RER, for example its mean over the period is zero.

$R_{i(j)t}$: Remoteness index defined as the weighted distance to all trading partners of country $i$:

$$R_{it} = \sum_j w_{ji} D_{ij} \text{ for } i \neq j \text{ and with } w_{jt} = \frac{Y_{jt}}{\sum_j Y_{jt}} \text{ for all } i.$$

$B_{i(j)}{}^{TRANSIT}$: For each landlocked country i (j), we set a variable that takes the value 1 if the country j(i) is a neighbouring country ($B_{ij}=1$) and if j(i) is a coastal country $L_{j(i)}=1$, otherwise 0. Then for each landlocked country i(j), we sum the countries j(i) that have the value 1, i.e. the number of neighbour countries with sea access. For all the landlocked countries in the world, this number is between 0 and 5. Then, since we want $B_{i(j)t}{}^{TRANSIT}$ to capture a cost, we associate the highest value (6) when the number of coastal neighbours is 0, and then respectively 5, 4, 3, 2 and 1 for 1, 2, 3 and 4 coastal neighbours. Last, since a coastal country has no cost, we set $B_{i(j)}{}^{TRANSIT}$ to 0 if the country i is not landlocked. This variable is adjusted by $L_{i(j)}(1- B_{i(j)})$, i.e. it is set to 0 for costal countries and for trade between neighbouring countries.

$D_{i(j)}{}^{PORT}$: Distance measured in kilometres between the main city in country $i$ (mostly the capital city) and access to the nearest port. The data come from Faye et al. (2005) and the authors' calculations. This variable is adjusted by $L_{i(j)}(1- B_{i(j)})$, i.e. it is set to 0 for costal countries and for trade between neighbouring countries.

$K_{it}{}^{TRANSIT}$: Average value of infrastructure for transit countries if a country is landlocked, 0 otherwise. Appendix A.6 lists the landlocked countries with the respective transit countries they use. Since we want to capture the cost associated with landlockedness, we use the inverse of the variable. Again, $1/K_{it}{}^{TRANSIT}$ is adjusted by $L_{i(j)}(1- B_{i(j)})$, i.e. it is set to 0 for costal countries and for trade between neighbouring countries.

$CA_{i(j)}$: Dummy equal to one if i (j) is a Central Asian country, 0 otherwise.